

have also been shown when results on a stress ECG were ambiguous or, conversely, when there were abnormal stress ECG findings in an asymptomatic patient. The correlation with anatomical abnormalities of the coronary arteries is good, but not absolute. Ischemia can be due to, and has been shown to occur in, coronary artery spasm, prolapsing mitral valve syndrome and asymmetrical septal hypertrophy.

A perfusion defect can also be found in acute myocardial infarction, but the lesion cannot be differentiated from scar and fibrosis due to old disease.

To show the presence of ischemic lesions, a two-part examination is done. In the first part, the tracer is injected intravenously at the time of maximal exercise. If the myocardial image is normal, no other scintigraphic procedure is required; if it is abnormal, a rest study is done at a later time. Defects present both at rest and exercise are considered due to old damage. Those present only with exercise are classified as ischemic lesions.

In summary, regional myocardial perfusion can be evaluated with ease in a variety of circumstances using thallium chloride 201. The procedure is noninvasive, sensitive and reproducible, and undoubtedly will be applied in showing perfusion abnormalities in a variety of circumstances as experience with the technique is gained.

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Radionuclide Imaging in Metastatic and Metabolic Bone Disease

RADIONUCLIDE BONE IMAGING has proved to be a useful diagnostic test for the early detection of metastatic bone disease. During the past three or four years with the advent of technetium-99m-labeled phosphate agents, bone imaging procedures are now generally available in the medical community. It has been shown that with these newer agents the sensitivity of metastatic bone lesion detection by means of radionuclide imaging approaches 98 percent. In contrast, skeletal radiographic studies show less than 50 percent of lesions. However, since the abnormalities detected by radionuclide imaging are not specific for any

particular disease, it is advisable to correlate these findings with all available clinical data, especially results of radiographic studies.

Although bone imaging has been extensively used for the detection and evaluation of metastatic bone disease, primary bone tumors, fractures, osteomyelitis and arthritis, the value of this technique in the detection and evaluation of bone lesions due to metabolic bone disease such as primary or secondary hyperparathyroidism has been recognized only recently. A recent study has shown that radionuclide bone imaging is more sensitive than radiography or bone calcium estimations by photon absorptiometry in the detection of bone lesions associated with metabolic disease. Such lesions, in contrast to neoplastic lesions, are more commonly located in the distal appendicular skeleton. It should be noted, however, that the abnormalities detected by radionuclide imaging in metabolic bone disease are similar to those associated with metastatic neoplasm and therefore they must be correlated with clinical data including radiographic findings.

In summary, radionuclide bone imaging is a superior diagnostic test, not only for the detection of metastatic bone disease but for the detection and evaluation of metabolic bone disease as well. The bone scan is the most sensitive indicator of skeletal disease. Conversely, an imaging study that shows no abnormalities usually excludes the presence of skeletal disease. Less than 5 percent of bone metastases will be undetectable by scan.

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Radionuclide Studies of the Hip

A PAINFUL HIP and the need to evaluate the vascular supply to the femoral head are the usual reasons for requesting a radionuclide study. Two common techniques are (1) hipbone image, using technetium Tc 99m diphosphonate or a related technetium-phosphate compound and (2) bone marrow (BM) of the hip image, with technetium Tc 99m sulfur colloid, using the BM activity as an index of perfusion. Simultaneous

imaging of the hips allows comparison of right and left hip activities. Perfusion is considered absent if activity in the region of the femoral neck is below adjacent body background, probably present if activity equals background, and normal for increased activities. Bone activity is considered normal if activity in the region of the femoral head is equal to, or only slightly greater than, surrounding bone activity. Abnormal activity may be less than, or distinctly greater than, surrounding bone activity. Changes from a baseline value are also considered significant.

Infarcted bone undergoes a sequence of changes. Acutely there is simply the avascularity (negative area on bone scan); after several days there is an increasing osteoblastic reactivity surrounding the ischemic-avascular bone (bone scans become increasingly positive) over a period of weeks. The BM image shows decreased perfusion of the neck during the entire sequence. If revascularization occurs, commonly seen in Legg-Perthes disease, the BM study will show increasing activity and the bone study will return to normal.

Therefore, in patients with chronic avascular necrosis there will be a negative BM image and a positive bone image. This pattern would be expected also with trauma, sickle cell crises and tumors (and probably osteomyelitis). On the other hand, in a patient with osteoarthritis, frequently the major differential diagnosis in hip pain, there will be parallel changes in bone and BM activity, both increasing if there is active inflammation, both decreasing if there is relative disuse of the involved joint.

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Serum Ferritin

FERRITIN, the second most abundant iron protein in the body, can be measured in serum by means of a radioimmunoassay. Serum levels are proportional to the size of the body iron stores. They are more accurate indicators of iron deficiency than serum levels of iron or iron binding capacity or bone marrow aspirates stained for hemosiderin. As expected, mean values are higher in

men than in women, but in either case—and regardless of age—serum values under 12 ng per ml are almost invariably diagnostic of iron deficiency. Levels above 50 ng almost always exclude iron deficiency in the differential diagnosis of anemias. Each ferritin molecule is thought to consist of a ferric iron hydroxide phosphate core and a protein shell with a molecular weight of about 450,000. Found mainly in the cytoplasm of reticuloendothelial and liver cells, it is assumed to be an iron storage protein and regulator of iron metabolism. From a practical standpoint, the finding of an elevated serum ferritin level in an anemic patient would exclude iron deficiency and might obviate the need for bone marrow examination.

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Lung Scanning and the Detection of Pulmonary Emboli

Combined 81m-Krypton Ventilation/99m-Tc-macroaggregate Perfusion Scintigraphy

INTRAVENOUSLY INJECTED PARTICLES whose diameters range from 15 to 50 μ are carried through the right atrium and ventricle, and distribute themselves over the lung capillaries according to blood flow distribution. In the capillaries they remain trapped for an average of 30 minutes to 4 hours. If the particles are labeled with a gamma emitting isotope, the distribution of the blood flow to the lungs can be estimated by scintigraphy. therefore, perfusion abnormalities can be detected as "defects" in the scintigram.

But do perfusion defects represent pulmonary emboli? Not always, and the question has been argued with some passion over the years. Normal findings on perfusion scintigraphy almost eliminate the chance that a pulmonary embolism will be found, but all perfusion defects are not indicative of the presence of pulmonary emboli. On pulmonary angiography, emboli will be found respectively in 81 percent, 50 percent and 9 percent of cases with lobar, segmental and subsegmental defects shown on the perfusion scan. The specificity of the test increases if it can be shown that the corresponding lung lesion has a normal ventilation. In those cases the probability of finding emboli by angiography becomes 94 percent,